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EFFICIENCY STUDY OF THE DISTRICT OF COLUMBIA WATER POLLUTION CONTROL PLANT

Federal Water Pollution Control Administration
Charlottesville, Virginia

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NATIONAL TECHNICAL INFORMATION SERVICE

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INTRODUCTION

An operational efficiency study of the District of Columbia Water Pollution Control Plant was made by staff of the Chesapeake Field Station, Chesapeake Bay-Susquehanna River Basins Project, of the Federal Water Pollution Control Administration on November 9, 10, and 11, 1966. The purpose of the study was to verify the results of a daily composite sampling program carried out by the District of Columbia Department of Sanitary Engineering in order to establish the reliability of this data as input to a mathematical model of the Potomac Estuary. Total phosphates were also measured in order to determine the operational efficiency of a conventionally operated, large activated sludge plant in removing this nutrient.

A simplified schematic sketch of the plant is shown in Figure 1. The plant is operated similarly to most high rate activated sludge plants, except that the elutriation wash water and the filtrate from the vacuum filters are discharged to the final effluent pipe instead of being recirculated back to the beginning of the plant.

HISTORICAL DATA

The District of Columbia Department of Sanitary Engineering has established an intensive sampling program of the plant for operational control purposes. Flow proportional composites (24-hour) are collected by automatic samplers at the plant influent, primary settling effluent, secondary settling effluent, and final plant effluent.

These samples are analyzed daily for suspended solids and 5-day biochemical oxygen demand (BOD). Efficiencies based upon the operational sampling program of the District of Columbia for each month during 1965 and 1966 at the Final Plant Effluent Sampling Point are shown in Table 1. In addition, data on daily grab samples of the elutriation wash water are available from the District of Columbia operational sampling program.

There has been some question as to whether the "final effluent" sample is a representative one. This question was raised by an apparent difference between the "final effluent" sample results and the final effluent characteristics as calculated from reported characteristics of component parts.

The "final effluent" sample is collected from the plant outfall at a point which is reported to be below the entry of all of the various plant outflows. These outflows consist of (1) secondary clarifier effluent; (2) elutriation tank overflows; (3) periodic sludge (primary, secondary, or digester) by-passes;

and (4) periodic raw sewage by-passes. Thus, the total amount of material discharged from the four sources enumerated above should be equivalent to the amount of material found at the "final effluent" sampling point. However, the sum of the four source flows is consistently higher with respect to solids and BOD_5 than that found at the "final effluent" sampling point. The following example for April 1965 is typical. All of the data shown is based on information contained in plant operating records.

APRIL 1965

SOURCE	SUSPENDED SOLIDS FLOW (lb/day)
Secondary effluent	55,710
Elutriation overflow	11,894
Secondary sludge	71,224
Raw sewage	17,728
	156,556
"Final effluent" data	109,733

These data show that in April only two-thirds of the solids reported as being discharged in the four component flows was picked up in the "final effluent" sample. This anomaly was consistent throughout the year and usually applied to the BOD_5 load as well. In no case did the "final effluent" sample load exceed the calculated total load.

THIS STUDY

The study involved analysis for 5-day BOD, suspended solids, and total organic carbon every two hours for a 48-hour period, and total phosphorus every four hours for a 30-hour period at the following sampling points shown on Figure 1:

A. Plant Influent

B. Secondary Effluent

C. Vacuum Filter Filtrate

D. Elutriation Wash Water

E. Final Effluent (D. C. Sampling Point)

F. Final Effluent (Final Manhole)

Sampling Point F was chosen at a manhole approximately 25 yards down from the final effluent sampling point of the District of Columbia. This was done to provide a check because of the previously described apparent difference between the final effluent values at Point E and those from a material balance of the component waste loads.

The analytical results of sampling during the study are shown in Tables 2-7. Plant flows as recorded by plant flow meters are shown in Figure 2.

Using the measured flows and concentrations, the values in Table 8 were computed. Values measured by District of Columbia are also shown in Table 8.

DISCUSSION

Except for the elutriation wash water, there is reasonably good agreement between the values as computed from the study samples and the values measured by the District of Columbia. Since the District of Columbia values on the elutriation wash water are based on only three grab samples, this difference is not unexpected. In every case the final efficiency as determined by the Field Station is within five per cent of the values as determined by the District of Columbia. (Table 9)

The apparent difference between efficiencies represented by concentration of the final effluent samples and the calculated concentration from a materials balance which has consistently occurred in the historic records was not observed during this study. The differences in plant efficiencies calculated both ways using either the Chesapeake Field Station data or the District of Columbia data are small and well within normal sampling error. The over-all efficiency of the plant (greater than 70 per cent removal of 5-day BOD) was higher than efficiencies indicated by the historical data for the same period during previous years.

The concentration of all parameters measured was higher at the final manhole sampling point (F) than that measured at the District of Columbia final effluent sampling point (E). This difference is small and is consistent. This indicates that the

District of Columbia sampling point, while slightly underestimating the gross load to the river, is representative of the total load to the Potomac River.

CONCLUSIONS

1. The efficiency of the District of Columbia Water Pollution Control Plant on November 9 and 10 was 70 per cent removal of BOD and 57 per cent removal of suspended solids.

2. During the study period the differences in plant efficiency when calculated using the District of Columbia final sampling point, the final manhole sampling point, and a material balance were small and of little significance to our use of this data for planning purposes.

3. The decrease in plant efficiency caused by the addition of elutriation wash water to the final effluent is significant.

TABLE 1

EFFICIENCY BASED ON DISTRICT OF COLUMBIA
"FINAL EFFLUENT" SAMPLES
(Per Cent Removal)

MONTH	1965 BOD	1965 SS	1966 BOD	1966 SS
January	58	48	37	23
February	66	63	14	26
March	62	56	62	55
April	65	53	58	59
May	70	69	63	63
June	67	69	63	70
July	69	64	40	74
August	67	67	56	52
September	63	58	74	75
October	51	49	73	74
November	51	31	73	69
December	51	46	63	68
Annual	62	53	56	59

TABLE 2

ANALYTICAL RESULTS - PLANT INFLUENT
SAMPLING STATION A
(mg/l)

Date	Time	5-Day BOD	Suspended Solids	Total Organic Carbon	Total Phosphate
Nov. 9, 1966	1000	186.5	107	90.1	
	1200	220.5	110	115.4	24.542
	1400	225.5	139	128.0	
	1600		142	172.6	35.317
	1800	197.0	127	152.0	
	2000	186.0	119	141.0	38.908
	2200	167.5	115	154.0	
Nov. 10, 1966	0002	219.0	111	144.6	31.845
	0203	243.0	184	134.0	
	0406	200.5	119	113.4	24.302
	0601	125.0	92	81.2	
	0800	143.5	79	81.4	17.580
	1000	90.5	86	72.0	16.990
	1200	152.5	179	121.6	
	1400	154.0	276	105.0	20.412
	1600	171.5	153	115.6	
	1800	199.5	157	122.2	33.510
	2000	181.0	173	151.6	
	2200	191.0	120	122.2	32.329
Nov. 11, 1966	0005	235.5	107	127.6	
	0200	225.0	313	145.0	
	0400	188.5	109	90.6	
	0600	143.5	104	89.6	
	0800	109.0	97	87.6	
	1000	131.5	114	82.4	
	1200	161.0	No Sample	83.0	

TABLE 3

ANALYTICAL RESULTS - SECONDARY EFFLUENT
SAMPLING STATION B
(mg/l)

Date	Time	5-Day BOD	Suspended Solids	Total Organic Carbon	Total Phosphate
Nov. 9, 1966	1000	38.0	24	31.3	
	1230	19.0	26	30.3	20.592
	1417	23.0	18	29.3	
	1625	38.7	22	31.7	19.274
	1825	28.6	18	29.9	
	2025	28.9	21	33.2	22.746
	2225	43.3	28	36.8	
Nov. 10, 1966	0016	35.5	17	36.8	26.936
	0220	39.9	18	35.0	
	0421	29.7	16	37.0	25.740
	0617	40.0	6	53.8	
	0800	26.6	6	33.2	24.660
	1000	33.9	5	35.3	21.356
	1215	30.4	30	34.1	
	1418	33.8	19	33.2	14.866
	1625	26.5	25	31.5	
	1825	34.5	31	34.7	14.512
	2025	34.3	20	33.5	
	2225	36.8	25	33.3	22.064
Nov. 11, 1966	0020	36.1	19	33.0	
	0215	37.9	26	33.5	
	0415	40.5	23	34.3	
	0618	38.9	24	34.1	
	0800	36.3	33	34.3	
	1000	31.6	26	30.6	
	1200	30.2	No Sample	30.2	

TABLE 4

ANALYTICAL RESULTS - VACUUM FILTER FILTRATE
SAMPLING STATION C
(mg/l)

Date	Time	5-Day BOD	Suspended Solids	Total Organic Carbon	Total Phosphate
Nov. 9, 1966	1000	370	186	181.2	
	1225	230	347	157.0	106.191
	1412	280	178	180.8	
	1620	292	49	157.2	108.466
	1820	331	67	158.0	
	2020	316	271	216.6	127.741
	2220	222	83	154.6	
Nov. 10, 1966	0013	237	53	133.2	98.290
	0215	221	39	129.4	
	0418	243	32	129.6	87.396
	0613	257	26	183.8	
	0800	335	160	181.0	117.639
	1000	266	172	174.8	109.734
	1212	333	302	211.0	
	1414	331	86*	172.6	122.359
	1620	427	3334	408.0	
	1820	287	270	210.0	121.179
	2020	266	--	145.6	
	2220	323	276	196.6	127.078
Nov. 11, 1966	0017	228	56	163.6	
	0212	261	47	147.2	
	0412	264	40	146.6	
	0615	246	27	143.4	
	0800	344	228	212.0	
	1000	348	79	170.6	
	1200	309	No Sample	165.8	

* Was upside down in box

TABLE 5

ANALYTICAL RESULTS - ELUTRIATION WASH WATER
SAMPLING STATION D
(mg/l)

Date	Time	5-Day BOD	Suspended Solids	Total Organic Carbon	Total Phosphate
Nov. 9, 1966	1000	762.0	1070	695	
	1215	796.0	2620	1040	188.799
	1407	388.0	2100	840	
	1610	816.0	1650	1126	116.248
	1810	124.0	240	70.8	
	2010	304.0	1640	754	132.770
	2210	598.0	1680	717	
Nov. 10, 1966	0008	552.0	1010	640	86.438
	0209	710.0	168	700	
	0412	455.0	2030	936	221.124
	0607	434.0	1260	686	
	0800	637.0	1150	525	113.863
	1000	661.0	1720	770	161.296
	1207	494.0	2330	850	
	1409	447.0	1420	630	127.078
	1610	559.0	1650	816	
	1810	757.0	2940	1000	176.636
	2010	609.0	1850	746	
	2210	482.0	1950	559	115.279
Nov. 11, 1966	0011	343.0	1140	348	
	0206	275.0	780	437	
	0406	405.0	420	418	
	0609	152.0	6940	580	
	0800	451.0	1200	490	
	1000	219.0	870	463	
	1200	524.0	No Sample	665	

TABLE 6
ANALYTICAL RESULTS - FINAL EFFLUENT (D. C. SAMPLING POINT)
SAMPLING STATION E
(mg/l)

Date	Time	5-Day BOD	Suspended Solids	Total Organic Carbon	Total Phosphate
Nov. 9, 1966	1000	44.5	28	38.2	
	1210	39.8	26	35.0	22.627
	1405	35.3	35	35.3	
	1605	68.2	--	47.5	20.950
	1805	59.2	134	49.7	
	2005	35.0	58	51.3	24.302
	2205	36.3	52	43.2	
Nov. 10, 1966	0005	46.9	34	42.5	26.337
	0205	47.4	53	44.0	
	0409	62.6	90	76.3	32.803
	0604	21.4	73	74.5	
	0800	54.4	53	51.8	28.790
	1205	42.1	44	47.0	
	1405	34.9	39	38.0	16.872
	1605	49.2	109	58.8	
	1805	66.8	124	77.0	21.238
	2005	48.3	50	46.5	
	2205	42.8	50	41.4	21.710
Nov. 11, 1966	0008	50.5	37	43.4	
	0203	43.4	44	44.0	
	0403	50.1	50	46.5	
	0603	54.1	61	50.5	
	0800	53.7	71	48.6	
	1000	46.4	59	45.6	
	1200	39.8	No Sample	38.3	

TABLE 7

ANALYTICAL RESULTS - FINAL EFFLUENT (FINAL MANHOLE)
SAMPLING STATION F
(mg/l)

Date	Time	5-Day BOD	Suspended Solids	Total Organic Carbon	Total Phosphate
Nov. 9, 1966	1000	50.2	6	34.0	
	1220	36.8	7	32.0	21.070
	1410	42.2	16	29.5	
	1615	74.0	80	61.5	23.823
	1815	>147	--	800.0	
	2015	26.8	24	36.8	23.344
	2215	35.0	46	40.0	
Nov. 10, 1966	0010	50.8	27	37.9	28.732
	0213	45.0	260	38.3	
	0415	65.0	52	55.8	33.640
	0610	86.8	136	126.8	
	0800	54.8	40	41.6	26.430
	1000	18.4	12	36.0	22.300
	1200	37.2	22	34.5	
	1411	29.6	28	29.5	16.282
	1615	22.8	37	34.3	
	1815	70.8	142	75.1	24.896
	2015	44.0	55	46.5	
	2215	37.4	28	38.0	22.418
Nov. 11, 1966	0014	30.4	17	36.2	
	0209	48.4	32	38.5	
	0409	52.0	62	51.8	
	0612	98.2	134	86.6	
	0800	115.4	260	128.6	
	1000	73.6	138	68.0	
	1200	--------No Sample Taken----------			

TABLE 8

AVERAGE MEASURED CONCENTRATIONS
(mg/l)

Sampling Point	CFS RESULTS* BOD	CFS RESULTS* Suspended Solids	CFS RESULTS* Total Organic Carbon	CFS RESULTS* Total Phosphate (as P)	D. C. RESULTS** BOD	D. C. RESULTS** Suspended Solids
A. Plant Influent	178	137	116	27.6	172	139
B. Secondary Effluent	34	21	34	21.3	30	23
C. Vacuum Filter Filtrate	291	151	178	112.6	208***	151***
D. Elutriation Wash Water	498	1,677	673	143.9	1,157***	2,227***
E. Final Effluent (D. C. Sampling Point)	47	60	49	24.0	47	59
F. Final Effluent (Final Manhole)	56	69	52	24.3	---	---

* Weighted average (according to slow) of 25 samples collected at 2-hour intervals from 10:00 A.M. on September 9 to 12:00 Noon on September 11, 1966.

** Average of November 9, 10, and 11, 1966.

*** Based on a single grab sample each day.

TABLE 9

EFFICIENCIES
(Per Cent Removal)

Sampling Point	CFS				D. C.	
	BOD	Suspended Solids	Total Organic Carbon	Total Phosphate	BOD	Suspended Solids
Secondary Effluent	81	84	71	23	83	83
Final Effluent (D. C. Sampling Point)	75	60	61	20	73	58
Final Effluent (Final Manhole)	70	57	58	12	--	--
Final Effluent (Computed from Material Balance)	77	67	63	15	73	62

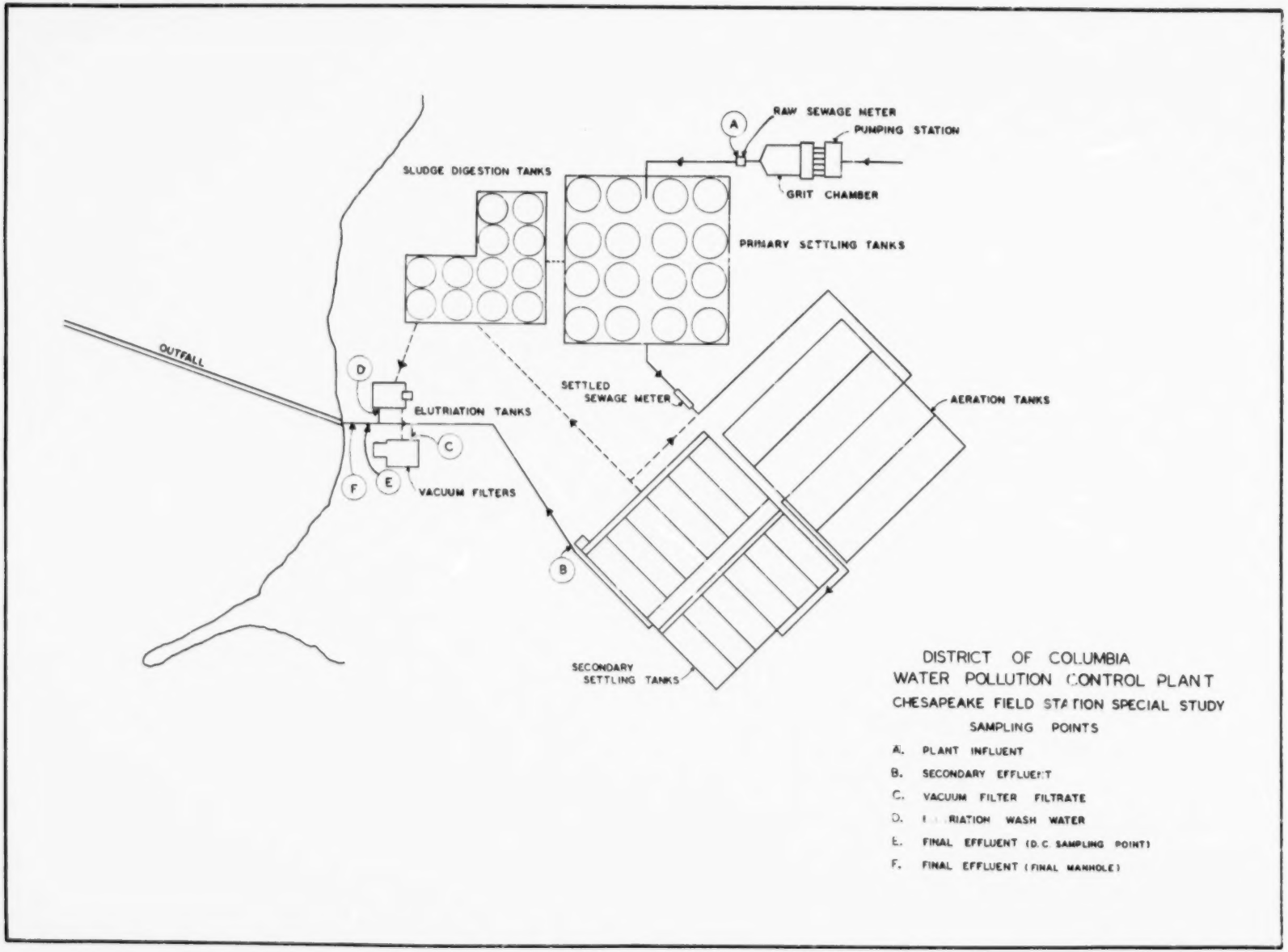
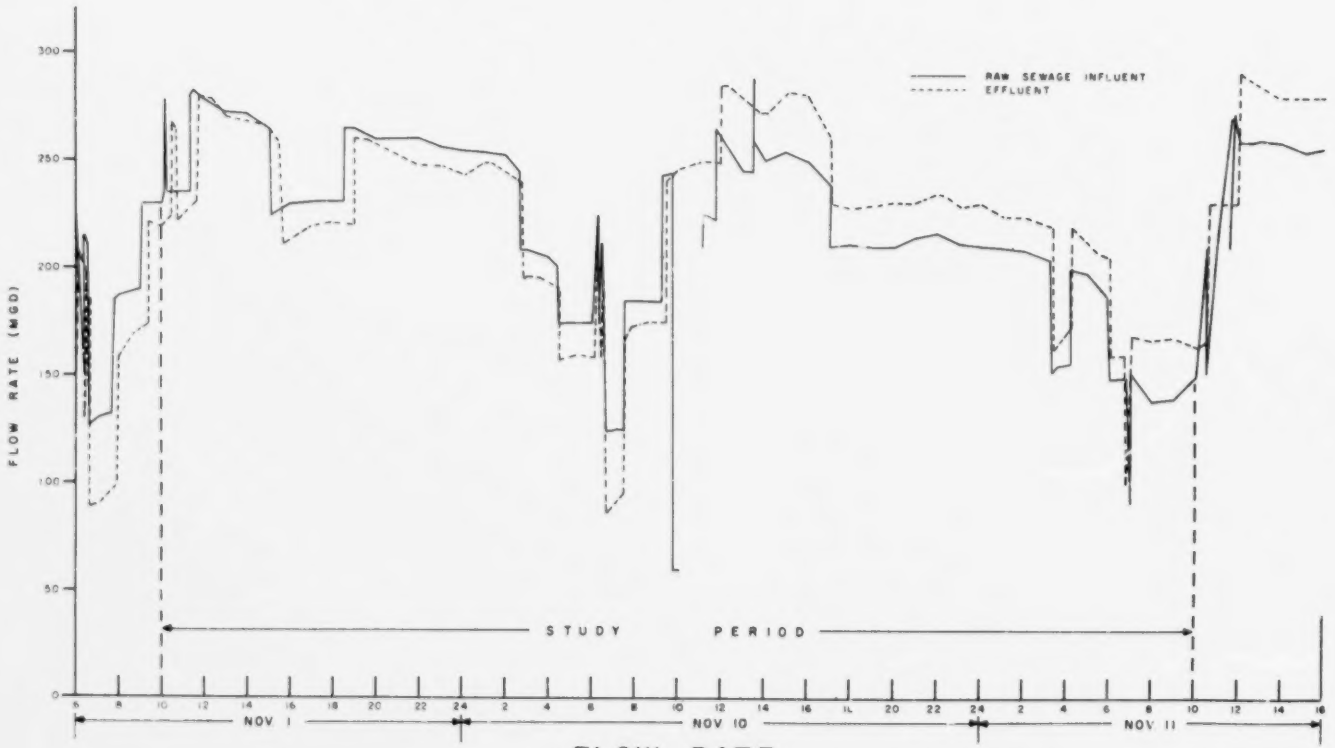

A
RAW SEWAGE METER
PUMPING STATION
GRIT CHAMBER
SLUDGE DIGESTION TANKS
PRIMARY SETTLING TANKS
OUTFALL
D
ELUTRIATION TANKS
SETTLED SEWAGE METER
AERATION TANKS
C
F
E
VACUUM FILTERS
B
SECONDARY SETTLING TANKS
DISTRICT OF COLUMBIA
WATER POLLUTION CONTROL PLANT
CHESAPEAKE FIELD STATION SPECIAL STUDY
SAMPLING POINTS
A. PLANT INFLUENT
B. SECONDARY EFFLUENT
C. VACUUM FILTER FILTRATE
D. ELUTRIATION WASH WATER
E. FINAL EFFLUENT (D.C. SAMPLING POINT)
F. FINAL EFFLUENT (FINAL MANHOLE)

FIGURE 1



FLOW RATE

DISTRICT OF COLUMBIA WATER POLLUTION CONTROL PLANT
CHESAPEAKE FIELD STATION SPECIAL STUDY

FIGURE 2

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